Introduction to Anatomy Unit-Module 1: Introduction
class="introduction"
Blood Pressure

A proficiency in anatomy and physiology is fundamental to any career in the health professions. (credit: Bryan Mason/flickr)

Note:
Chapter Objectives
After studying this chapter, you will be able to:

- Distinguish between anatomy and physiology, and identify several branches of each
- Describe the structure of the body, from simplest to most complex, in terms of the levels of organization
- Identify the functional characteristics of human life
- Identify the requirements for human survival
- Define homeostasis and explain its importance to normal human functioning
- Use appropriate anatomical terminology to identify key body structures, body regions, and directions in the body
- Appreciate how form reflects function in the human body

Though you may approach a course in anatomy and physiology strictly as a requirement for your field of study, the knowledge you gain in this course will serve you well in many aspects of your life. An understanding of anatomy and physiology is not only fundamental to any career in the health professions, but it can also benefit your own health. Familiarity with the human body can help you make healthful choices and prompt you to take appropriate action when signs of illness arise. Your knowledge in this field will help you understand news about nutrition, medications, medical devices, and procedures and help you understand genetic or infectious diseases. At some point, everyone will have a problem with some aspect of his or her body and your knowledge can help you to be a better parent, spouse, partner, friend, colleague, or caregiver.

This chapter begins with an overview of anatomy and physiology and a preview of the body regions and functions. It then covers the characteristics of life and how the body works to maintain stable conditions. It introduces a set of standard terms for body structures and for planes and positions in the body that will serve as a foundation for more comprehensive information

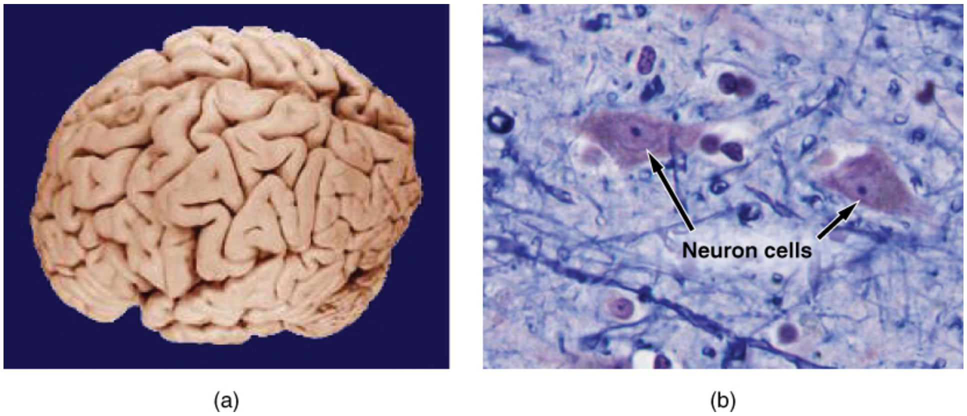
covered later in the text. It ends with examples of medical imaging used to see inside the living body.

Introduction to Anatomy Module 2: Overview of Anatomy and Physiology
By the end of this section, you will be able to:

- Compare and contrast anatomy and physiology, including their specializations and methods of study
- Discuss the fundamental relationship between anatomy and physiology

Human **anatomy** is the scientific study of the body's **structures**. Some of these structures are very small and can only be observed and analyzed with the assistance of a microscope. Other larger structures can readily be seen, manipulated, measured, and weighed. The word "anatomy" comes from a Greek root that means "to cut apart." Human anatomy was first studied by observing the exterior of the body and observing the wounds of soldiers and other injuries. Later, physicians were allowed to dissect bodies of the dead to increase their knowledge. When a body is dissected, its structures are cut apart in order to observe their physical attributes and their relationships to one another. Dissection is still used in medical schools, anatomy courses, and in pathology labs. In order to observe structures in living people, however, a number of imaging techniques have been developed. These techniques allow clinicians to visualize structures inside the living body such as a cancerous tumor or a fractured bone.

Like most scientific disciplines, anatomy has areas of specialization. **Gross anatomy** is the study of the larger structures of the body, those visible without the aid of magnification ([link]**a**). Macro- means "large," thus, gross anatomy is also referred to as macroscopic anatomy. In contrast, micro- means "small," and **microscopic anatomy** is the study of structures that can be observed only with the use of a microscope or other magnification devices ([link]**b**). Microscopic anatomy includes cytology, the study of cells and histology, the study of tissues. As the technology of microscopes has advanced, anatomists have been able to observe smaller and smaller structures of the body, from slices of large structures like the heart, to the three-dimensional structures of large molecules in the body.
Gross and Microscopic Anatomy



(a) Gross anatomy considers large structures such as the brain. (b) Microscopic anatomy can deal with the same structures, though at a different scale. This is a micrograph of nerve cells from the brain. LM × 1600. (credit a: "WriterHound"/Wikimedia Commons; credit b: Micrograph provided by the Regents of University of Michigan Medical School © 2012)

Anatomists take two general approaches to the study of the body's structures: regional and systemic. **Regional anatomy** is the study of the interrelationships of all of the structures in a specific body region, such as the abdomen. Studying regional anatomy helps us appreciate the interrelationships of body structures, such as how muscles, nerves, blood vessels, and other structures work together to serve a particular body region. In contrast, **systemic anatomy** is the study of the structures that make up a discrete body system—that is, a group of structures that work together to perform a unique body function. For example, a systemic anatomical study of the muscular system would consider all of the skeletal muscles of the body.

Whereas anatomy is about structure, physiology is about **function**. Human **physiology** is the scientific study of the chemistry and physics of the structures of the body and the ways in which they work together to support the functions of life. Much of the study of physiology centers on the body's tendency toward homeostasis. **Homeostasis** is the state of steady internal

conditions maintained by living things. The study of physiology certainly includes observation, both with the naked eye and with microscopes, as well as manipulations and measurements. However, current advances in physiology usually depend on carefully designed laboratory experiments that reveal the functions of the many structures and chemical compounds that make up the human body.

Like anatomists, physiologists typically specialize in a particular branch of physiology. For example, neurophysiology is the study of the brain, spinal cord, and nerves and how these work together to perform functions as complex and diverse as vision, movement, and thinking. Physiologists may work from the organ level (exploring, for example, what different parts of the brain do) to the molecular level (such as exploring how an electrochemical signal travels along nerves).

Form is closely related to function in all living things. For example, bone tissue takes the form of a hard, strong substance. This form allows it to function well to protect vital organs like the brain and heart. Blood tissue is a liquid, allowing it to circulate quickly about the body, transporting vital substances like oxygen and nutrients.

Your study of anatomy and physiology will make more sense if you continually relate the form of the structures you are studying to their function. In fact, it can be somewhat frustrating to attempt to study anatomy without an understanding of the physiology that a body structure supports. Imagine, for example, trying to appreciate the unique arrangement of the bones of the human hand if you had no conception of the function of the hand. Fortunately, your understanding of how the human hand manipulates tools—from pens to cell phones—helps you appreciate the unique alignment of the thumb in opposition to the four fingers, making your hand a structure that allows you to pinch and grasp objects and type text messages.

Chapter Review

Human anatomy is the scientific study of the body’s structures. In the past, anatomy has primarily been studied via observing injuries, and later by the

dissection of anatomical structures of cadavers, but in the past century, computer-assisted imaging techniques have allowed clinicians to look inside the living body. Human physiology is the scientific study of the chemistry and physics of the structures of the body. Physiology explains how the structures of the body work together to maintain life. It is difficult to study structure (anatomy) without knowledge of function (physiology). The two disciplines are typically studied together because form and function are closely related in all living things.

Glossary

anatomy
: science that studies the form and composition of the body’s structures

gross anatomy
: study of the larger structures of the body, typically with the unaided eye; also referred to macroscopic anatomy

homeostasis
: steady state of body systems that living organisms maintain

microscopic anatomy
: study of very small structures of the body using magnification

physiology
: science that studies the chemistry, biochemistry, and physics of the body’s functions

regional anatomy
: study of the structures that contribute to specific body regions

systemic anatomy
: study of the structures that contribute to specific body systems

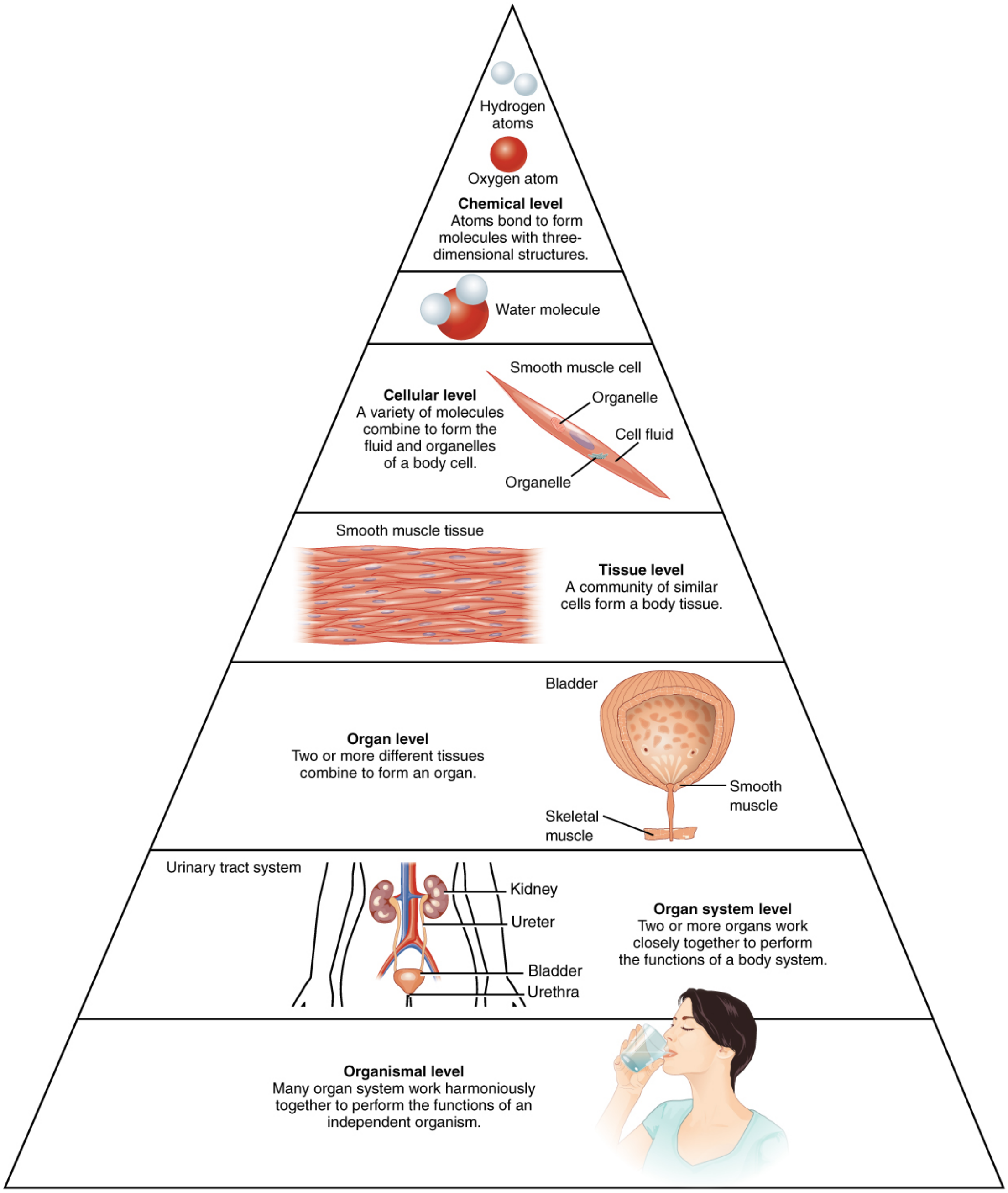
Introduction to Anatomy Module 3: Structural Organization of the Human Body

By the end of this section, you will be able to:

- Describe the structure of the human body in terms of six levels of organization
- List the eleven organ systems of the human body and identify at least one organ and one major function of each

Before you begin to study the different structures and functions of the human body, it is helpful to consider its basic architecture; that is, how its smallest parts are assembled into larger structures. It is convenient to consider the structures of the body in terms of fundamental levels of organization that increase in complexity: subatomic particles, atoms, molecules, organelles cells, tissues, organs, organ systems, organisms and biosphere ([link]).

Levels of Structural Organization of the Human Body



The organization of the body often is discussed in terms of six distinct levels of increasing complexity, from the smallest chemical building blocks to a unique human organism.

The Levels of Organization

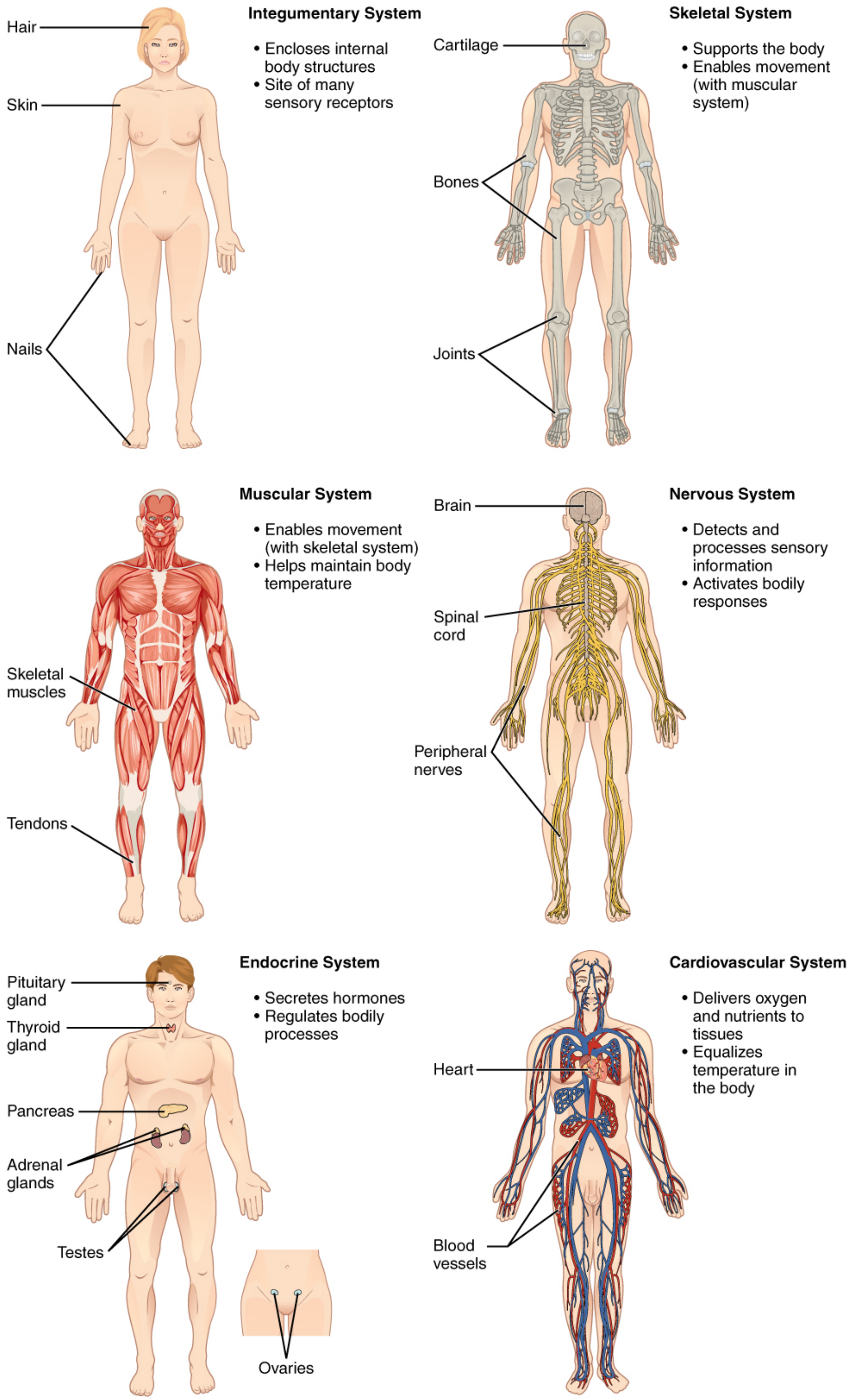
To study the chemical level of organization, scientists consider the simplest building blocks of matter: subatomic particles, atoms and molecules. All matter in the universe is composed of one or more unique pure substances called elements, familiar examples of which are hydrogen, oxygen, carbon, nitrogen, calcium, and iron. The smallest unit of any of these pure substances (elements) is an atom. Atoms are made up of subatomic particles such as the proton, electron and neutron. Two or more atoms combine to form a molecule, such as the water molecules, proteins, and sugars found in living things. Molecules are the chemical building blocks of all body structures.

A **cell** is the smallest independently functioning unit of a living organism. Even bacteria, which are extremely small, independently-living organisms, have a cellular structure. Each bacterium is a single cell. All living structures of human anatomy contain cells, and almost all functions of human physiology are performed in cells or are initiated by cells.

A human cell typically consists of flexible membranes that enclose cytoplasm, a water-based cellular fluid together with a variety of tiny functioning units called **organelles**. In humans, as in all organisms, cells perform all functions of life. A **tissue** is a group of many similar cells (though sometimes composed of a few related types) that work together to perform a specific function. An **organ** is an anatomically distinct structure of the body composed of two or more tissue types. Each organ performs one or more specific physiological functions. An **organ system** is a group of organs that work together to perform major functions or meet physiological needs of the body.

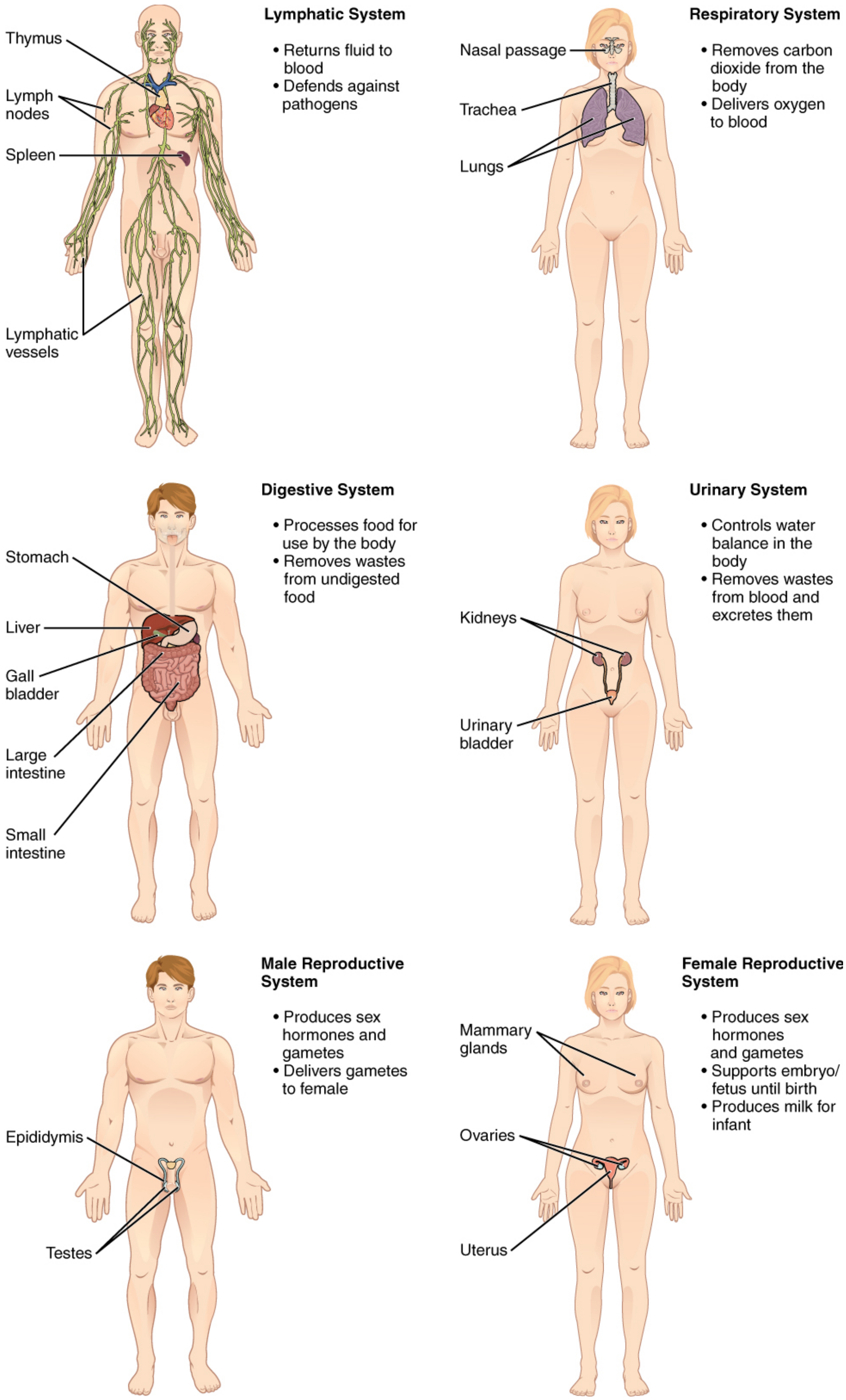
This book covers eleven distinct organ systems in the human body ([link] and [link]). Assigning organs to organ systems can be imprecise since organs that “belong” to one system can also have functions integral to another system. In fact, most organs contribute to more than one system.

Organ Systems of the Human Body


Integumentary System
• Encloses internal body structures
• Site of many sensory receptors
Hair
Skin
Nails
Skeletal System
• Supports the body
• Enables movement (with muscular system)
Cartilage
Bones
Joints
Muscular System
• Enables movement (with skeletal system)
• Helps maintain body temperature
Skeletal muscles
Tendons
Nervous System
• Detects and processes sensory information
• Activates bodily responses
Brain
Spinal cord
Peripheral nerves
Endocrine System
• Secretes hormones
• Regulates bodily processes
Pituitary gland
Thyroid gland
Pancreas
Adrenal glands
Testes
Ovaries
Cardiovascular System
• Delivers oxygen and nutrients to tissues
• Equalizes temperature in the body
Heart
Blood vessels

Organs that work together are grouped into organ systems.

Organ Systems of the Human Body (continued)


Lymphatic System
• Returns fluid to blood
• Defends against pathogens
Thymus
Lymph nodes
Spleen
Lymphatic vessels
Respiratory System
• Removes carbon dioxide from the body
• Delivers oxygen to blood
Nasal passage
Trachea
Lungs
Digestive System
• Processes food for use by the body
• Removes wastes from undigested food
Stomach
Liver
Gall bladder
Large intestine
Small intestine
Urinary System
• Controls water balance in the body
• Removes wastes from blood and excretes them
Kidneys
Urinary bladder
Male Reproductive System
• Produces sex hormones and gametes
• Delivers gametes to female
Epididymis
Testes
Female Reproductive System
• Produces sex hormones and gametes
• Supports embryo/fetus until birth
• Produces milk for infant
Mammary glands
Ovaries
Uterus

Organs that work together are grouped into organ systems.

The organism level is the highest level of organization. An **organism** is a living being that has a cellular structure and that can independently perform all physiologic functions necessary for life. In multicellular organisms, including humans, all cells, tissues, organs, and organ systems of the body work together to maintain the life and health of the organism. All of the living organisms in our world can be referred to as the biosphere.

Chapter Review

Life processes of the human body are maintained at several levels of structural organization. These include the chemical, cellular, tissue, organ, organ system, and the organism level. Higher levels of organization are built from lower levels. Therefore, molecules combine to form cells, cells combine to form tissues, tissues combine to form organs, organs combine to form organ systems, and organ systems combine to form organisms.

Review Questions

Exercise:

Problem:

The smallest independently functioning unit of an organism is a(n) ________.

a. cell
b. molecule
c. organ
d. tissue

Solution:

A

Exercise:

Problem:

A collection of similar tissues that performs a specific function is an ________.

a. organ
b. organelle
c. organism
d. organ system

Solution:

A

Exercise:

Problem:

The body system responsible for structural support and movement is the ________.

a. cardiovascular system
b. endocrine system
c. muscular system
d. skeletal system

Solution:

D

CRITICAL THINKING QUESTIONS

Exercise:

Problem: Name the six levels of organization of the human body.

Solution:

Chemical, cellular, tissue, organ, organ system, organism.

Exercise:

Problem:

The female ovaries and the male testes are a part of which body system? Can these organs be members of more than one organ system? Why or why not?

Solution:

The female ovaries and the male testes are parts of the reproductive system. But they also secrete hormones, as does the endocrine system, therefore ovaries and testes function within both the endocrine and reproductive systems.

Glossary

cell
: smallest independently functioning unit of all organisms; in animals, a cell contains cytoplasm, composed of fluid and organelles

organ
: functionally distinct structure composed of two or more types of tissues

organ system
: group of organs that work together to carry out a particular function

organism
: living being that has a cellular structure and that can independently perform all physiologic functions necessary for life

tissue

group of similar or closely related cells that act together to perform a specific function

Introduction to Anatomy Module 4: Functions of Human Life
By the end of this section, you will be able to:

- Explain the importance of organization to the function of the human organism
- Distinguish between metabolism, anabolism, and catabolism
- Provide at least two examples of human responsiveness and human movement
- Compare and contrast growth, differentiation, and reproduction

The different organ systems each have different functions and therefore unique roles to perform in physiology. These many functions can be summarized in terms of a few that we might consider definitive of human life: organization, metabolism, responsiveness, movement, development, and reproduction.

Organization

A human body consists of trillions of cells organized in a way that maintains distinct internal compartments. These compartments keep body cells separated from external environmental threats and keep the cells moist and nourished. They also separate internal body fluids from the countless microorganisms that grow on body surfaces, including the lining of certain tracts, or passageways. The intestinal tract, for example, is home to even more bacteria cells than the total of all human cells in the body, yet these bacteria are outside the body and cannot be allowed to circulate freely inside the body.

Cells, for example, have a cell membrane (also referred to as the plasma membrane) that keeps the intracellular environment—the fluids and organelles—separate from the extracellular environment. Blood vessels keep blood inside a closed circulatory system, and nerves and muscles are wrapped in connective tissue sheaths that separate them from surrounding structures. In the chest and abdomen, a variety of internal membranes keep major organs such as the lungs, heart, and kidneys separate from others.

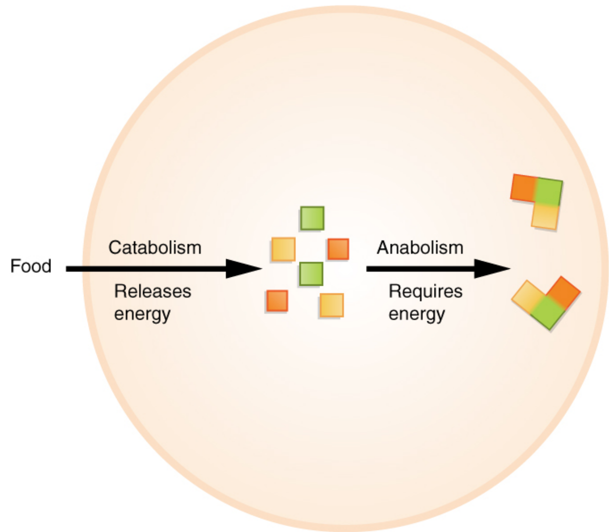
The body’s largest organ system is the integumentary system, which includes the skin and its associated structures, such as hair and nails. The surface tissue of skin is a barrier that protects internal structures and fluids from potentially harmful microorganisms and other toxins.

Metabolism

The first law of thermodynamics holds that energy can neither be created nor destroyed—it can only change form. Your basic function as an organism is to consume (ingest) energy and molecules in the foods you eat, convert some of it into fuel for movement, sustain your body functions, and build and maintain your body structures. There are two types of reactions that accomplish this: **anabolism** and **catabolism**.

- **Anabolism** is the process whereby smaller, simpler molecules are combined into larger, more complex substances. Your body can assemble, by utilizing energy, the complex chemicals it needs by combining small molecules derived from the foods you eat
- **Catabolism** is the process by which larger more complex substances are broken down into smaller simpler molecules. Catabolism releases energy. The complex molecules found in foods are broken down so the body can use their parts to assemble the structures and substances needed for life.

Taken together, these two processes are called metabolism. **Metabolism** is the sum of all anabolic and catabolic reactions that take place in the body ([link]). Both anabolism and catabolism occur simultaneously and continuously to keep you alive.
Metabolism



Anabolic reactions are building reactions, and they consume energy. Catabolic reactions break materials down and release energy. Metabolism includes both anabolic and catabolic reactions.

Every cell in your body makes use of a chemical compound, **adenosine triphosphate (ATP)**, to store and release energy. The cell stores energy in the synthesis (anabolism) of ATP, then moves the ATP molecules to the location where energy is needed to fuel cellular activities. Then the ATP is broken down (catabolism) and a controlled amount of energy is released, which is used by the cell to perform a particular job.

Note:

View this animation to learn more about metabolic processes. What kind of catabolism occurs in the heart?

Responsiveness

Responsiveness is the ability of an organism to adjust to changes in its internal and external environments. An example of responsiveness to external stimuli could include moving toward sources of food and water and away from perceived dangers. Changes in an organism’s internal environment, such as increased body temperature, can cause the responses of sweating and the dilation of blood vessels in the skin in order to decrease body temperature, as shown by the runners in [link].

Movement

Human movement includes not only actions at the joints of the body, but also the motion of individual organs and even individual cells. As you read these words, red and white blood cells are moving throughout your body, muscle cells are contracting and relaxing to maintain your posture and to focus your vision, and glands are secreting chemicals to regulate body functions. Your body is coordinating the action of entire muscle groups to enable you to move air into and out of your lungs, to push blood throughout your body, and to propel the food you have eaten through your digestive tract. Consciously, of course, you contract your skeletal muscles to move the bones of your skeleton to get from one place to another (as the runners are doing in [link]), and to carry out all of the activities of your daily life.

Marathon Runners

Runners demonstrate two characteristics of living humans—responsiveness and movement. Anatomic structures and physiological processes allow runners to coordinate the action of muscle groups and sweat in response to rising internal body temperature. (credit: Phil Roeder/flickr)

Development, growth and reproduction

Development is all of the changes the body goes through in life. Development includes the processes of differentiation, growth, and renewal.

Growth is the increase in body size. Humans, like all multicellular organisms, grow by increasing the number of existing cells, increasing the amount of non-cellular material around cells (such as mineral deposits in bone), and, within very narrow limits, increasing the size of existing cells.

Reproduction is the formation of a new organism from parent organisms. In humans, reproduction is carried out by the male and female reproductive

systems. Because death will come to all complex organisms, without reproduction, the line of organisms would end.

Chapter Review

Most processes that occur in the human body are not consciously controlled. They occur continuously to build, maintain, and sustain life. These processes include: organization, in terms of the maintenance of essential body boundaries; metabolism, including energy transfer via anabolic and catabolic reactions; responsiveness; movement; and growth, differentiation, reproduction, and renewal.

Interactive Link Questions

Exercise:

Problem:

View this animation to learn more about metabolic processes. What kind of catabolism occurs in the heart?

Solution:

Fatty acid catabolism.

Review Questions

Exercise:

Problem: Metabolism can be defined as the _________.

a. adjustment by an organism to external or internal changes
b. process whereby all unspecialized cells become specialized to perform distinct functions
c. process whereby new cells are formed to replace worn-out cells
d. sum of all chemical reactions in an organism

Solution:

D

Exercise:

Problem:

Adenosine triphosphate (ATP) is an important molecule because it _________.

a. is the result of catabolism
b. release energy in uncontrolled bursts
c. stores energy for use by body cells
d. All of the above

Solution:

C

Exercise:

Problem:

Cancer cells can be characterized as “generic” cells that perform no specialized body function. Thus cancer cells lack _________.

a. differentiation
b. reproduction
c. responsiveness
d. both reproduction and responsiveness

Solution:

A

CRITICAL THINKING QUESTIONS

Exercise:

Problem:

Explain why the smell of smoke when you are sitting at a campfire does not trigger alarm, but the smell of smoke in your residence hall does.

Solution:

When you are sitting at a campfire, your sense of smell adapts to the smell of smoke. Only if that smell were to suddenly and dramatically intensify would you be likely to notice and respond. In contrast, the smell of even a trace of smoke would be new and highly unusual in your residence hall, and would be perceived as danger.

Exercise:

Problem:

Identify three different ways that growth can occur in the human body.

Solution:

Growth can occur by increasing the number of existing cells, increasing the size of existing cells, or increasing the amount of non-cellular material around cells.

Glossary

anabolism
: assembly of more complex molecules from simpler molecules

catabolism
: breaking down of more complex molecules into simpler molecules

development

changes an organism goes through during its life

differentiation
: process by which unspecialized cells become specialized in structure and function

growth
: process of increasing in size

metabolism
: sum of all of the body’s chemical reactions

renewal
: process by which worn-out cells are replaced

reproduction
: process by which new organisms are generated

responsiveness
: ability of an organisms or a system to adjust to changes in conditions

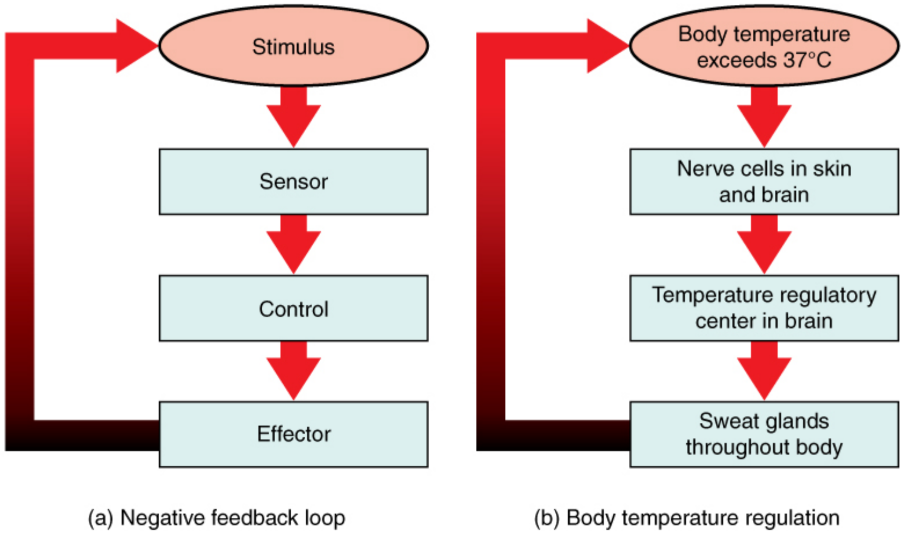
Introduction to Anatomy Module 5: Homeostasis
By the end of this section, you will be able to:

- Discuss the role of homeostasis in healthy functioning
- Contrast negative and positive feedback, giving one physiologic example of each mechanism

Maintaining homeostasis requires that the body continuously monitor its internal conditions. From body temperature to blood pressure to levels of certain nutrients, each condition has a particular set point. A **set point** is the value around which the normal range fluctuates. A **normal range** is the set of values that is most healthful and stable. For example, the set point for normal human body temperature is approximately 98.6°F. Physiological conditions, such as body temperature and blood pressure, tend to fluctuate within a normal range a few degrees above and below that point. Control centers in the brain play roles in keeping them within the normal range. As the body works to maintain homeostasis, any significant change from the normal range will be resisted and homeostasis will be restored through a process called negative feedback. **Negative feedback** is a mechanism that prevents a condition from going beyond the normal range by reversing the action once the normal range is exceeded. Negative feedback serves to make the variation smaller, so the imbalance is lessened. The maintenance of homeostasis by negative feedback goes on throughout the body at all times, and an understanding of negative feedback is thus fundamental to an understanding of human physiology.

Negative Feedback

A negative feedback system has three basic components ([link]**a**). A **receptor**, is a part of a feedback system that monitors a physiological value (temperature for example). This value is reported to a control center such as the brain. The **control center** is the part in a feedback system that compares the value to the normal range. If the value deviates too much from the set point, then the control center activates an effector. An **effector** is the part in a feedback system that causes a change to reverse the situation and return the value to the normal range.
Negative Feedback Loop



In a negative feedback loop, a stimulus—a deviation from a set point—is resisted through a physiological process that returns the body to homeostasis. (a) A negative feedback loop has four basic parts. (b) Body temperature is regulated by negative feedback.

When a stimulus drives a value is outside of the normal range, the system is set in motion. The value must be beyond its normal range (that is, beyond homeostasis). This abnormal value is detected by a specific sensor. For example, in the control of blood glucose, specific cells in the pancreas detect excess glucose (the stimulus) in the bloodstream. These pancreatic cells respond to the increased level of blood glucose by releasing the hormone insulin into the bloodstream. The insulin signals skeletal muscle fibers, fat cells and liver cells to take up the excess glucose, removing it from the bloodstream. As glucose concentration in the bloodstream returns to normal, the decrease in concentration—the actual negative feedback—is detected by pancreatic cells, and insulin release stops. This prevents blood sugar levels from continuing to drop below the normal range.

Humans have a similar temperature regulation feedback system that works by promoting either heat loss or heat gain ([link]**b**). When the brain’s temperature regulation center receives data from the sensors indicating that

the body’s temperature exceeds its normal range, it stimulates a cluster of brain cells referred to as the “heat-loss center.” This stimulation has three major effects:

- Blood vessels in the skin begin to dilate (widen) allowing more blood from the body core to flow to the surface of the skin allowing the heat to radiate into the environment.
- As blood flow to the skin increases, sweat glands are activated to increase their output. As the sweat evaporates from the skin surface into the surrounding air, it takes heat with it.
- The depth of respiration increases, and a person may breathe through an open mouth instead of through the nasal passageways. This further increases heat loss from the lungs.

In contrast, when the brain senses the body becoming too cool:

- Blood flow to the skin, and blood returning from the limbs is diverted into a network of deep veins. This arrangement traps heat closer to the body core and restricts heat loss.
- If heat loss is severe, the brain triggers an increase in random signals to skeletal muscles, causing them to contract and producing shivering. The muscle contractions of shivering release heat while using up ATP.
- The brain triggers the thyroid gland in the endocrine system to release thyroid hormone, which increases metabolic activity and heat production in cells throughout the body.

Note:

openstax COLLEGE

Water concentration in the body is critical for proper functioning. A person’s body retains very tight control on water levels without conscious

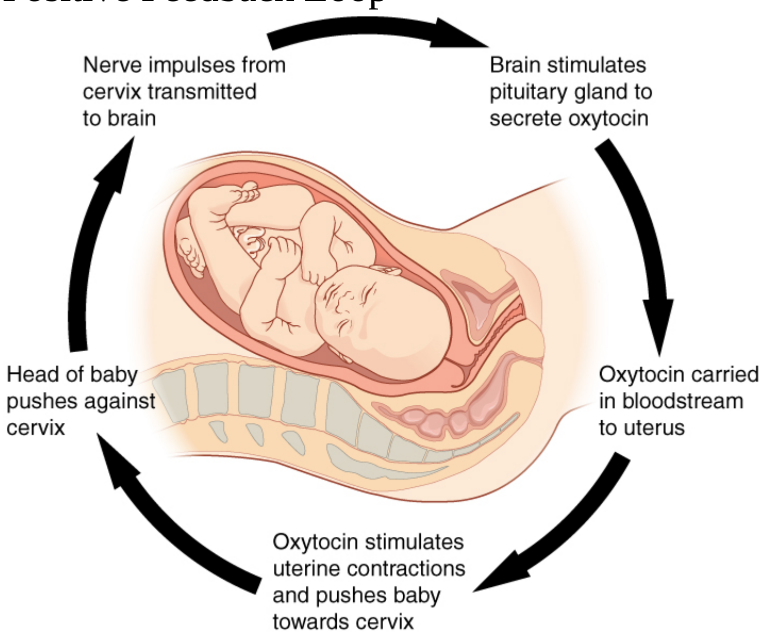
control by the person. Watch this video to learn more about water concentration in the body. Which organ has primary control over the amount of water in the body?

Positive Feedback

Positive feedback intensifies a change in the body's condition rather than reversing it. A deviation from the normal range results in more change, and the system moves farther away from the normal range. Positive feedback in the body is normal only when there is a definite end point. Childbirth, fever, lactation (breast feeding) and the body's response to blood loss are examples of positive feedback loops that are normal but are activated only when needed.

Childbirth at full term is an example of a situation in which the maintenance of the existing body state is not desired. Enormous changes in the mother's body are required to expel the baby at the end of pregnancy. And the events of childbirth, once begun, must progress rapidly to a conclusion or the life of the mother and the baby are at risk. The extreme muscular work of labor and delivery are the result of a positive feedback system ([link]).

Positive Feedback Loop



Normal childbirth is driven by a positive feedback loop. A positive feedback loop results in a change in the body's status, rather than a return to homeostasis.

The first contractions of labor push the baby toward the cervix (the lowest part of the uterus). The cervix contains stretch-sensitive nerve cells that monitor stretching. These nerve cells send messages to the brain, which in turn causes the brain to release the hormone oxytocin into the bloodstream. Oxytocin causes stronger contractions of the muscles in of the uterus, pushing the baby further down the birth canal. This causes even greater stretching of the cervix. The cycle of stretching, oxytocin release, and increasingly more forceful contractions stops only when the baby is born. At this point, the stretching of the cervix halts, stopping the release of oxytocin.

Both negative and positive feedback are considered to be **homeostatic mechanisms**. Homeostatic mechanisms help the body to restore and maintain a homeostatic balance. A negative feedback mechanism serves to make the unwanted change smaller, while a positive feedback mechanism increases the change before the body can return to homeostasis.

Chapter Review

Homeostasis is the activity of cells throughout the body to maintain the physiological state within a narrow range that is compatible with life. Homeostasis is regulated by negative feedback loops and, much less frequently, by positive feedback loops. Both have the same components of a stimulus, sensor, control center, and effector; however, negative feedback loops work to prevent an excessive response to the stimulus, whereas positive feedback loops intensify the response until an end point is reached.

Interactive Link Questions

Exercise:

Problem:

Water concentration in the body is critical for proper functioning. A person's body retains very tight control on water levels without conscious control by the person. Watch this video to learn more about water concentration in the body. Which organ has primary control over the amount of water in the body?

Solution:

The kidneys.

Review Questions

Exercise:

Problem:

After you eat lunch, nerve cells in your stomach respond to the distension (the stimulus) resulting from the food. They relay this information to ________.

a. a control center
b. a set point
c. effectors
d. sensors

Solution:

A

Exercise:

Problem: Stimulation of the heat-loss center causes ________.

a. blood vessels in the skin to constrict

b. breathing to become slow and shallow
c. sweat glands to increase their output
d. All of the above

Solution:

C

Exercise:

Problem:

Which of the following is an example of a normal physiologic process that uses a positive feedback loop?

a. blood pressure regulation
b. childbirth
c. regulation of fluid balance
d. temperature regulation

Solution:

B

Critical Thinking Questions

Exercise:

Problem:

Identify the four components of a negative feedback loop and explain what would happen if secretion of a body chemical controlled by a negative feedback system became too great.

Solution:

The four components of a negative feedback loop are: stimulus, sensor, control center, and effector. If too great a quantity of the chemical were excreted, sensors would activate a control center, which would in turn activate an effector. In this case, the effector (the secreting cells) would be adjusted downward.

Exercise:

Problem:

What regulatory processes would your body use if you were trapped by a blizzard in an unheated, uninsulated cabin in the woods?

Solution:

Any prolonged exposure to extreme cold would activate the brain's heat-gain center. This would reduce blood flow to your skin, and shunt blood returning from your limbs away from the digits and into a network of deep veins. Your brain's heat-gain center would also increase your muscle contraction, causing you to shiver. This increases the energy consumption of skeletal muscle and generates more heat. Your body would also produce thyroid hormone and epinephrine, chemicals that promote increased metabolism and heat production.

Glossary

control center
: compares values to their normal range; deviations cause the activation of an effector

effector
: organ that can cause a change in a value

negative feedback
: homeostatic mechanism that tends to stabilize an upset in the body's physiological condition by preventing an excessive response to a stimulus, typically as the stimulus is removed

normal range
: range of values around the set point that do not cause a reaction by the control center

positive feedback
: mechanism that intensifies a change in the body's physiological condition in response to a stimulus

sensor
: (also, receptor) reports a monitored physiological value to the control center

set point
: ideal value for a physiological parameter; the level or small range within which a physiological parameter such as blood pressure is stable and optimally healthful, that is, within its parameters of homeostasis

Introduction to Anatomy Module 6A and 6B: Anatomical Terminology
By the end of this section, you will be able to:

- Demonstrate the anatomical position
- Describe the human body using directional and regional terms
- Identify three planes most commonly used in the study of anatomy
- Distinguish between the posterior (dorsal) and the anterior (ventral) body cavities, identifying their subdivisions and representative organs found in each
- Describe serous membrane and explain its function

Anatomists and health care providers use terminology that can be confusing. However, the purpose of this language is not to confuse, but rather to increase precision and reduce medical errors. For example, is a scar "above the wrist" located on the forearm two or three inches away from the hand? Or is it at the base of the hand? Is it on the palm-side or back-side? **By using anatomical terminology, we can be more precise**. Anatomical terms derive from ancient Greek and Latin words. Because these languages are no longer used in everyday conversation, the meaning of their words does not change.

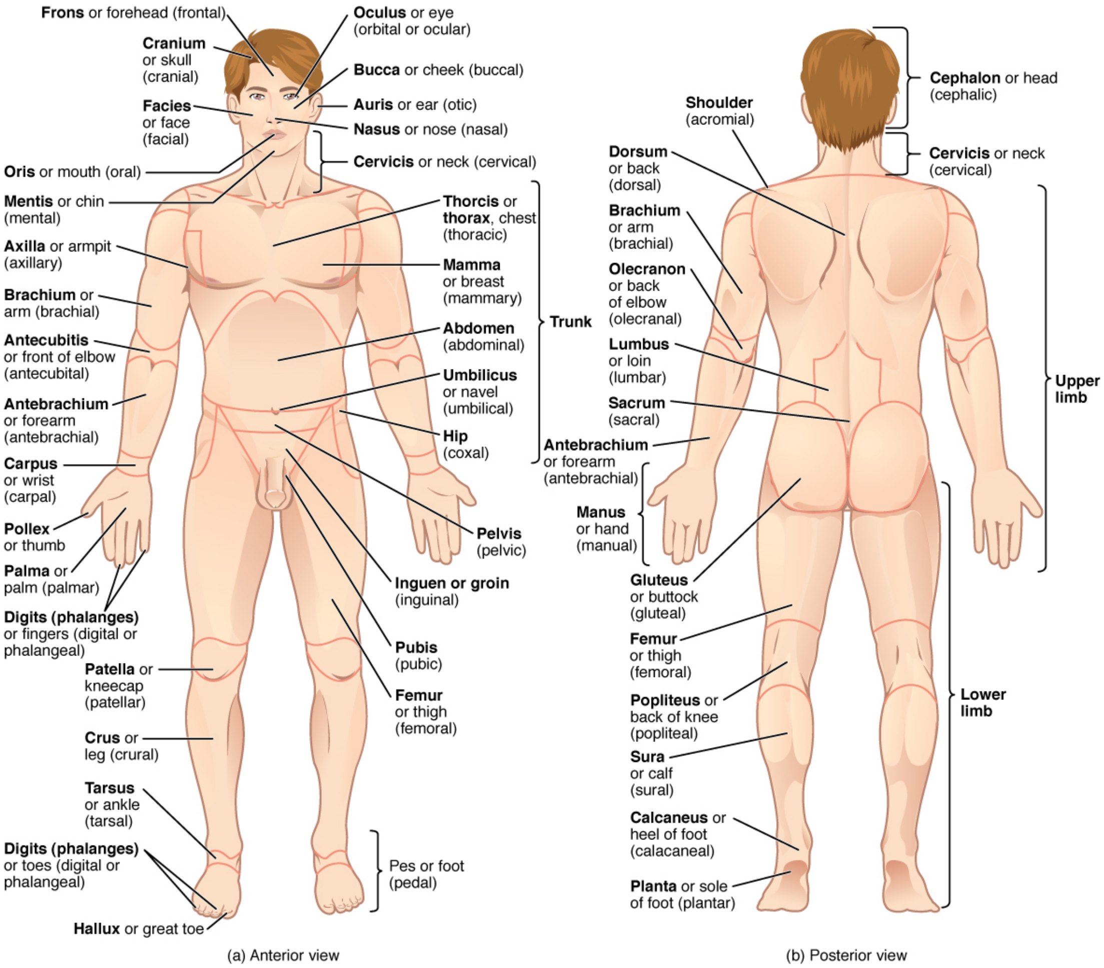
Anatomical terms are made up of roots, prefixes, and suffixes. The root of a term often refers to an organ, tissue, or condition, whereas the prefix or suffix often describes the root. For example, in the disorder hypertension, the prefix "hyper-" means "high" or "over," and the root word "tension" refers to pressure, so the word "hypertension" refers to abnormally high blood pressure.

Anatomical Position

To further increase precision, anatomists standardize the way in which they view the body. Just as maps are normally oriented with north at the top, the standard body "map," or **anatomical position**, is that of the body standing upright, with the feet at shoulder width and parallel, toes forward. The upper limbs are held out to each side, and the palms of the hands face forward as illustrated in [link]. Using this standard position reduces confusion. It does not matter how the body being described is oriented, the

terms are used as if it is in anatomical position. For example, a scar in the “anterior (front) carpal (wrist) region” would be present on the palm side of the wrist. The term “anterior” would be used even if the hand were palm down on a table.

Regions of the Human Body



The human body is shown in anatomical position in an (a) anterior view and a (b) posterior view. The regions of the body are labeled in boldface.

A body that is lying down is described as either prone or supine. **Prone** describes a face-down orientation, and **supine** describes a face up orientation. These terms are sometimes used in describing the position of the body during specific physical examinations or surgical procedures.

Regional Terms

The human body’s numerous regions have specific terms to help increase precision (see [link]). Notice that the term “brachium” or “arm” is reserved for the “upper arm” and “antebrachium” or “forearm” is used rather than “lower arm.” Similarly, “femur” or “thigh” is correct, and “leg” or “crus” is reserved for the portion of the lower limb between the knee and the ankle. You will be able to describe the body’s regions using the terms from the figure.

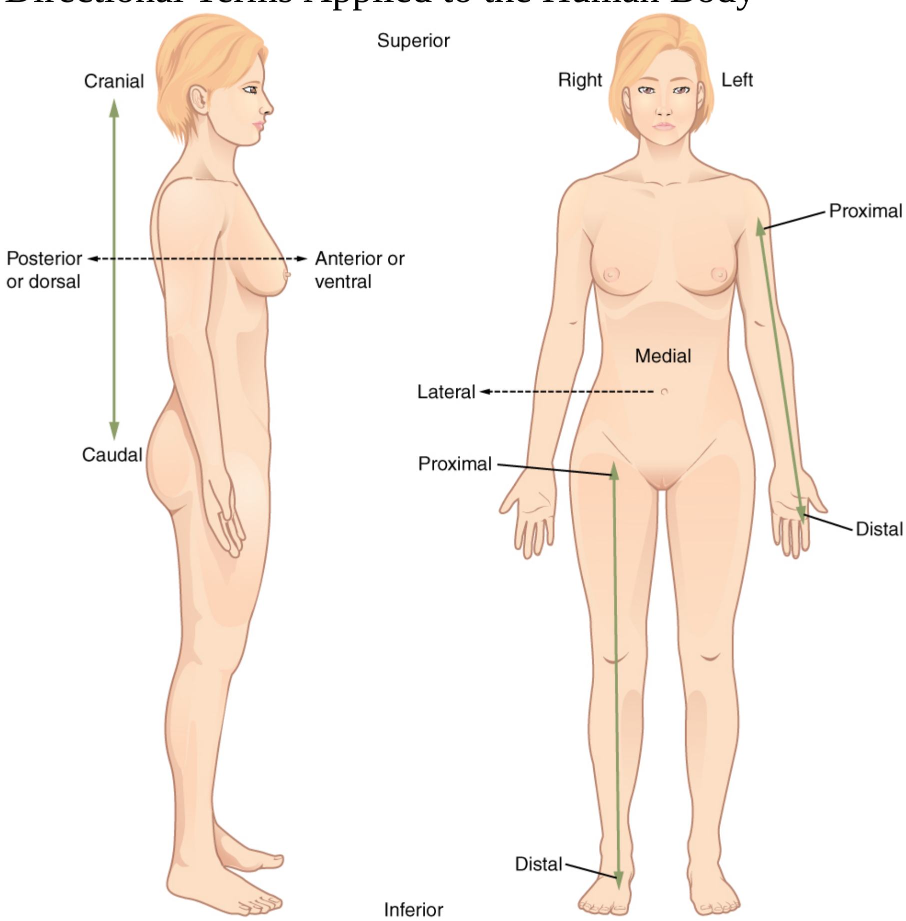
Directional Terms

Certain directional anatomical terms appear throughout this and any other anatomy textbook ([link]). These terms are essential for describing the relative locations of different body structures. For instance, an anatomist might describe one band of tissue as “inferior to” another or a physician might describe a tumor as “superficial to” a deeper body structure. Commit these terms to memory to avoid confusion when you are studying or describing the locations of particular body parts.

- **Anterior** (or **ventral**) Describes the front or direction toward the front of the body. The toes are anterior to the foot.
- **Posterior** (or **dorsal**) Describes the back or direction toward the back of the body. The popliteus is posterior to the patella.
- **Superior** (or **cranial**) describes a position above or higher than another part of the body proper. The orbits are superior to the oris.
- **Inferior** (or **caudal**) describes a position below or lower than another part of the body proper; near or toward the tail (in humans, the coccyx, or lowest part of the spinal column). The pelvis is inferior to the abdomen.
- **Lateral** describes the side or direction toward the side of the body. The thumb (pollex) is lateral to the digits.
- **Medial** describes the middle or direction toward the middle of the body. The hallux is the medial toe.
- **Proximal** describes a position in a limb that is nearer to the point of attachment or the trunk of the body. The brachium is proximal to the antebrachium.

- **Distal** describes a position in a limb that is farther from the point of attachment or the trunk of the body. The crus is distal to the femur.
- **Superficial** describes a position closer to the surface of the body. The skin is superficial to the bones.
- **Deep** describes a position farther from the surface of the body. The brain is deep to the skull.

Directional Terms Applied to the Human Body



Paired directional terms are shown as applied to the human body.

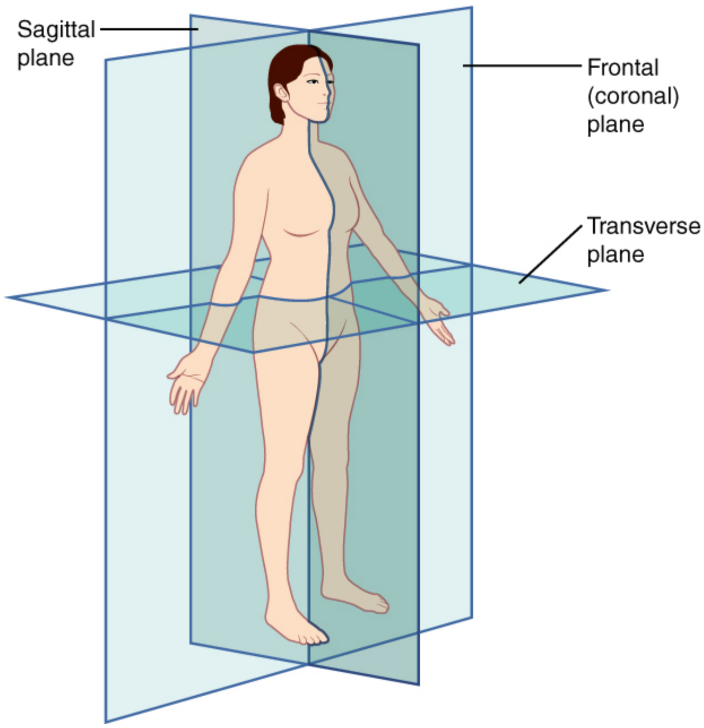
FOR MODULE 6A STOP READING. THE FOLLOWING SECTION IS MODULE 6B.

Body Planes

A **section** is a two-dimensional surface of a three-dimensional structure that has been cut. Modern medical imaging devices enable clinicians to obtain “virtual sections” of living bodies. We call these scans. Body sections and scans can be correctly interpreted, however, only if the viewer understands the plane along which the section was made. A **plane** is an imaginary two-dimensional surface that passes through the body. There are three planes commonly referred to in anatomy and medicine, as illustrated in [link].

- The **sagittal plane** is the plane that divides the body or an organ vertically into right and left sides. If this vertical plane runs directly down the middle of the body, it is called the **midsagittal** or median plane. If it divides the body into unequal right and left sides, it is called a parasagittal plane or less commonly a longitudinal section.
- The **frontal plane** is the plane that divides the body or an organ into an anterior (front) portion and a posterior (rear) portion. The frontal plane is often referred to as a coronal plane. (“Corona” is Latin for “crown.”)
- The **transverse plane** is the plane that divides the body or organ horizontally into upper and lower portions. Transverse planes produce images referred to as cross sections.

Planes of the Body

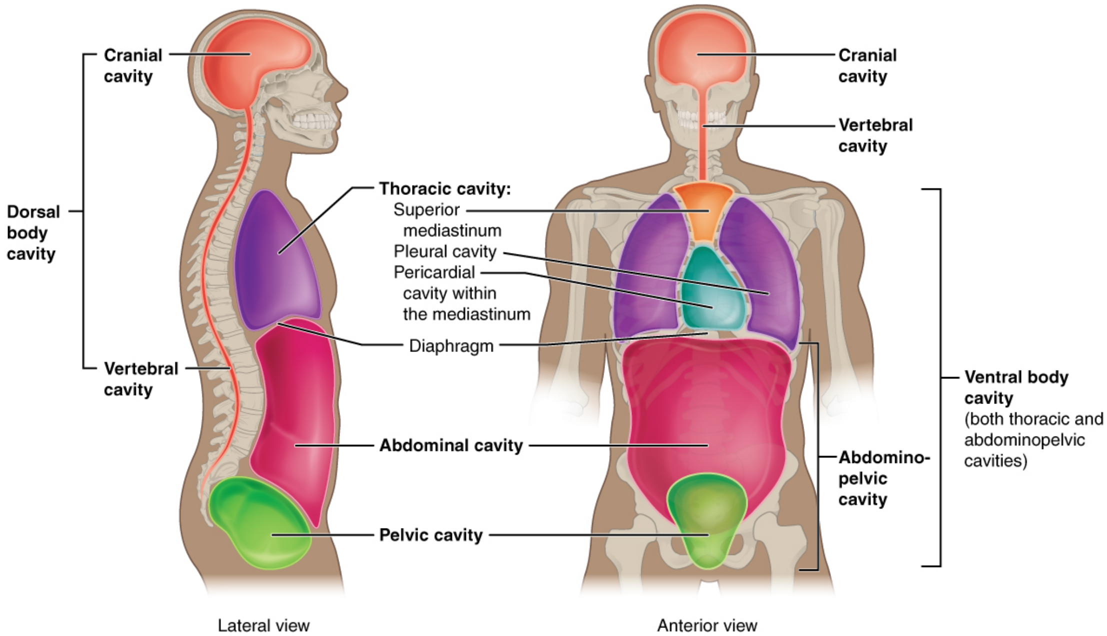


The three planes most commonly used in anatomical and medical imaging are the sagittal, frontal (or coronal), and transverse plane.

Body Cavities and Serous Membranes

The body maintains its internal organization by means of membranes, sheaths, and other structures that separate compartments. The **dorsal (posterior) cavity** and the **ventral (anterior) cavity** are the largest body compartments ([link]). These cavities contain and protect delicate internal organs, and the ventral cavity allows for significant changes in the size and shape of the organs as they perform their functions. The lungs, heart, stomach, and intestines, for example, can expand and contract without distorting other tissues or disrupting the activity of nearby organs.

Dorsal and Ventral Body Cavities



The ventral cavity includes the thoracic and abdominopelvic cavities and their subdivisions. The dorsal cavity includes the cranial and spinal cavities.

Subdivisions of the Posterior (Dorsal) and Anterior (Ventral) Cavities

The posterior (dorsal) and anterior (ventral) cavities are each subdivided into smaller cavities. In the posterior (dorsal) cavity, the **cranial cavity** houses the brain, and the **spinal cavity** (or vertebral cavity) encloses the spinal cord. Just as the brain and spinal cord make up a continuous, uninterrupted structure, the cranial and spinal cavities that house them are also continuous. The brain and spinal cord are protected by the bones of the skull and vertebral column and by cerebrospinal fluid, a colorless fluid produced by the brain, which cushions the brain and spinal cord within the posterior (dorsal) cavity.

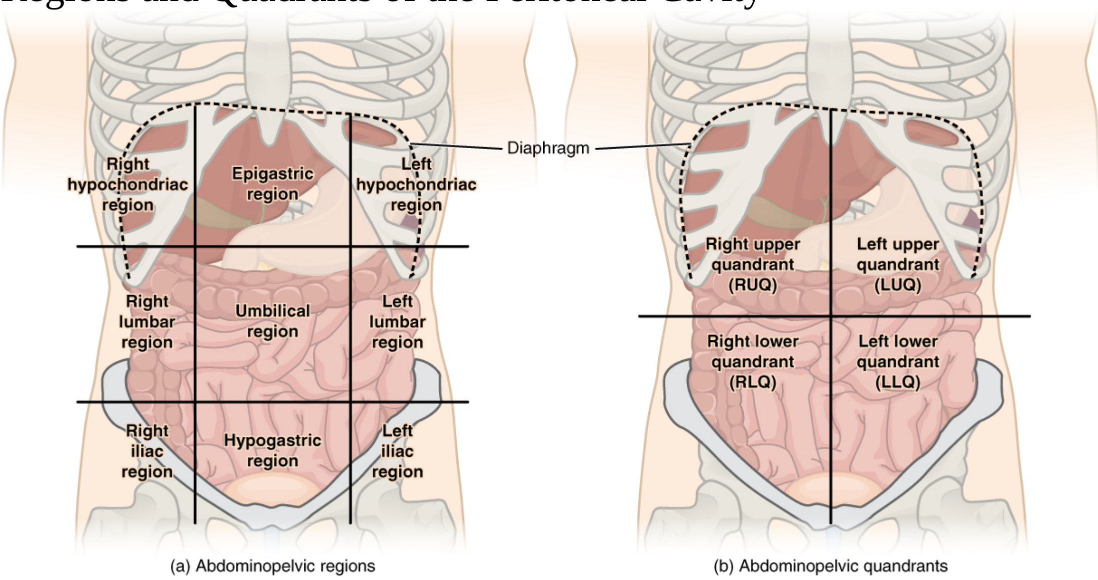
The anterior (ventral) cavity has two main subdivisions: the thoracic cavity and the abdominopelvic cavity (see [link]). The **thoracic cavity** is the more superior subdivision of the anterior cavity, and it is enclosed by the rib cage.

The thoracic cavity contains the lungs and the heart, which is located in the mediastinum. The diaphragm forms the floor of the thoracic cavity and separates it from the more inferior abdominopelvic cavity. The **abdominopelvic cavity** is the largest cavity in the body. Although no membrane physically divides the abdominopelvic cavity, it can be useful to distinguish between the abdominal cavity, the division that houses the digestive organs, and the pelvic cavity, the division that houses the organs of reproduction.

Abdominal Regions and Quadrants

To promote clear communication, for instance about the location of a patient's abdominal pain or a suspicious mass, health care providers typically divide up the cavity into either nine regions or four quadrants ([link]).

Regions and Quadrants of the Peritoneal Cavity



There are (a) nine abdominal regions and (b) four abdominal quadrants in the peritoneal cavity.

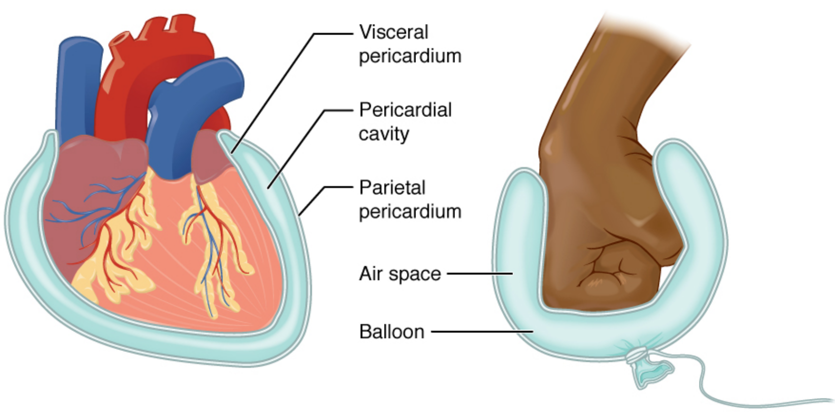
The more detailed regional approach subdivides the cavity with one horizontal line immediately inferior to the ribs and one immediately superior to the pelvis, and two vertical lines drawn as if dropped from the midpoint of each clavicle (collarbone). There are nine resulting regions. The simpler quadrants approach, which is more commonly used in medicine, subdivides the cavity with one horizontal and one vertical line that intersect at the patient's umbilicus (navel).

Membranes of the Anterior (Ventral) Body Cavity

A **serous membrane** (also referred to a serosa) is one of the thin membranes that cover the walls and organs in the thoracic and abdominopelvic cavities. The parietal layers of the membranes line the walls of the body cavity (pariet- refers to a cavity wall). The visceral layer of the membrane covers the organs (the viscera). Between the parietal and visceral layers is a very thin, fluid-filled serous space, or cavity ([link]).

- Visceral-pertaining to or in contact with an organ.
- Parietal pertaining to or in contact with a cavity wall.

Serous Membrane



Serous membrane lines the pericardial cavity and reflects back to cover the heart—much the same way that an underinflated balloon would form two layers surrounding a fist.

There are three serous cavities and their associated membranes. The **pleura** is the serous membrane that surrounds the lungs in the pleural cavity; the **pericardium** is the serous membrane that surrounds the heart in the pericardial cavity; and the **peritoneum** is the serous membrane that surrounds several organs in the abdominopelvic cavity. The serous membranes therefore provide protection to the viscera they enclose by reducing friction that could lead to inflammation of the organs.

Chapter Review

Ancient Greek and Latin words are used to build anatomical terms. A standard reference position for mapping the body's structures is the normal anatomical position. Regions of the body are identified using terms such as "occipital" that are more precise than common words and phrases such as "the back of the head." Directional terms such as anterior and posterior are essential for accurately describing the relative locations of body structures. Images of the body's interior commonly align along one of three planes: the sagittal, frontal, or transverse. The body's organs are organized in one of two main cavities—dorsal (also referred to posterior) and ventral (also referred to anterior)—which are further sub-divided according to the structures present in each area. The serous membranes have two layers—parietal and visceral—surrounding a fluid filled space. Serous membranes cover the lungs (pleural serosa), heart (pericardial serosa), and some abdominopelvic organs (peritoneal serosa).

Review Chapter

Exercise:

Problem:

What is the position of the body when it is in the "normal anatomical position?"

a. The person is prone with upper limbs, including palms, touching sides and lower limbs touching at sides.
b. The person is standing facing the observer, with upper limbs extended out at a ninety-degree angle from the torso and lower limbs in a wide stance with feet pointing laterally
c. The person is supine with upper limbs, including palms, touching sides and lower limbs touching at sides.
d. None of the above

Solution:

D

Exercise:

Problem:

To make a banana split, you halve a banana into two long, thin, right and left sides along the _________.

a. coronal plane
b. longitudinal plane
c. midsagittal plane
d. transverse plane

Solution:

C

Exercise:

Problem: The lumbar region is _________.

a. inferior to the gluteal region
b. inferior to the umbilical region
c. superior to the cervical region
d. superior to the popliteal region

Solution:

D

Exercise:

Problem: The heart is within the ________.

a. cranial cavity
b. mediastinum
c. posterior (dorsal) cavity
d. All of the above

Solution:

B

Critical Thinking Question

Exercise:

Problem:

In which direction would an MRI scanner move to produce sequential images of the body in the frontal plane, and in which direction would an MRI scanner move to produce sequential images of the body in the sagittal plane?

Solution:

If the body were supine or prone, the MRI scanner would move from top to bottom to produce frontal sections, which would divide the body into anterior and posterior portions, as in "cutting" a deck of cards. Again, if the body were supine or prone, to produce sagittal sections, the scanner would move from left to right or from right to left to divide the body lengthwise into left and right portions.

Exercise:

Problem:

If a bullet were to penetrate a lung, which three anterior thoracic body cavities would it enter, and which layer of the serous membrane would it encounter first?

Solution:

The bullet would enter the ventral, thoracic, and pleural cavities, and it would encounter the parietal layer of serous membrane first.

Glossary

abdominopelvic cavity
: division of the anterior (ventral) cavity that houses the abdominal and pelvic viscera

anatomical position
: standard reference position used for describing locations and directions on the human body

anterior
: describes the front or direction toward the front of the body; also referred to as ventral

anterior cavity
: larger body cavity located anterior to the posterior (dorsal) body cavity; includes the serous membrane-lined pleural cavities for the lungs, pericardial cavity for the heart, and peritoneal cavity for the abdominal and pelvic organs; also referred to as ventral cavity

caudal
: describes a position below or lower than another part of the body proper; near or toward the tail (in humans, the coccyx, or lowest part of the spinal column); also referred to as inferior

cranial
describes a position above or higher than another part of the body proper; also referred to as superior

cranial cavity
division of the posterior (dorsal) cavity that houses the brain

deep
describes a position farther from the surface of the body

distal
describes a position farther from the point of attachment or the trunk of the body

dorsal
describes the back or direction toward the back of the body; also referred to as posterior

dorsal cavity
posterior body cavity that houses the brain and spinal cord; also referred to the posterior body cavity

frontal plane
two-dimensional, vertical plane that divides the body or organ into anterior and posterior portions

inferior
describes a position below or lower than another part of the body proper; near or toward the tail (in humans, the coccyx, or lowest part of the spinal column); also referred to as caudal

lateral
describes the side or direction toward the side of the body

medial
describes the middle or direction toward the middle of the body

pericardium

sac that encloses the heart

peritoneum
serous membrane that lines the abdominopelvic cavity and covers the organs found there

plane
imaginary two-dimensional surface that passes through the body

pleura
serous membrane that lines the pleural cavity and covers the lungs

posterior
describes the back or direction toward the back of the body; also referred to as dorsal

posterior cavity
posterior body cavity that houses the brain and spinal cord; also referred to as dorsal cavity

prone
face down

proximal
describes a position nearer to the point of attachment or the trunk of the body

sagittal plane
two-dimensional, vertical plane that divides the body or organ into right and left sides

section
in anatomy, a single flat surface of a three-dimensional structure that has been cut through

serous membrane
membrane that covers organs and reduces friction; also referred to as serosa

serosa
: membrane that covers organs and reduces friction; also referred to as serous membrane

spinal cavity
: division of the dorsal cavity that houses the spinal cord; also referred to as vertebral cavity

superficial
: describes a position nearer to the surface of the body

superior
: describes a position above or higher than another part of the body proper; also referred to as cranial

supine
: face up

thoracic cavity
: division of the anterior (ventral) cavity that houses the heart, lungs, esophagus, and trachea

transverse plane
: two-dimensional, horizontal plane that divides the body or organ into superior and inferior portions

ventral
: describes the front or direction toward the front of the body; also referred to as anterior

ventral cavity
: larger body cavity located anterior to the posterior (dorsal) body cavity; includes the serous membrane-lined pleural cavities for the lungs, pericardial cavity for the heart, and peritoneal cavity for the abdominal and pelvic organs; also referred to as anterior body cavity

Introduction to Anatomy Module 7: Medical Imaging
By the end of this section, you will be able to:

- Discuss the uses and drawbacks of X-ray imaging
- Identify four modern medical imaging techniques and how they are used

For thousands of years, fear of the dead and legal sanctions limited the ability of anatomists and physicians to study the internal structures of the human body. An inability to control bleeding, infection, and pain made surgeries infrequent, and those that were performed—such as wound suturing, amputations, tooth and tumor removals, skull drilling, and cesarean births—did not greatly advance knowledge about internal anatomy. Theories about the function of the body and about disease were therefore largely based on external observations and imagination. During the fourteenth and fifteenth centuries, however, the detailed anatomical drawings of Italian artist and anatomist **Leonardo da Vinci** and Flemish anatomist **Andreas Vesalius** were published, and interest in human anatomy began to increase. Medical schools began to teach anatomy using human dissection; although some resorted to grave robbing to obtain corpses. Laws were eventually passed that enabled students to dissect the corpses of criminals and those who donated their bodies for research. Still, it was not until the late nineteenth century that medical researchers discovered non-surgical methods to look inside the living body.

X-Rays

German physicist **Wilhelm Röntgen** (1845–1923) was experimenting with electrical current when he discovered that a mysterious and invisible “ray” would pass through his flesh but leave an outline of his bones on a screen coated with a metal compound. In 1895, Röntgen made the first durable record of the internal parts of a living human: an “X-ray” image (as it came to be called) of his wife’s hand. Scientists around the world quickly began their own experiments with X-rays, and by 1900, X-rays were widely used to detect a variety of injuries and diseases. In 1901, Röntgen was awarded the first Nobel Prize for physics for his work in this field.

The **X-ray** is a form of **high energy electromagnetic radiation** with a short wavelength capable of penetrating solids and ionizing gases. As they are used in medicine, X-rays are emitted from an X-ray machine and directed toward a specially treated metallic plate placed behind the patient's body. The beam of radiation results in darkening of the X-ray plate. X-rays are slightly impeded by soft tissues, which show up as gray on the X-ray plate, whereas hard tissues, such as bone, largely block the rays, producing a light-toned "shadow." Thus, X-rays are best used to visualize hard body structures such as teeth and bones ([link]). Like many forms of high energy radiation, however, X-rays are capable of damaging cells and initiating changes that can lead to cancer. This danger of excessive exposure to X-rays was not fully appreciated for many years after their widespread use.

X-Ray of a Hand

High energy electromagnetic radiation allows the internal structures of the body, such as bones, to be seen in X-rays like these. (credit: Trace Meek/flickr)

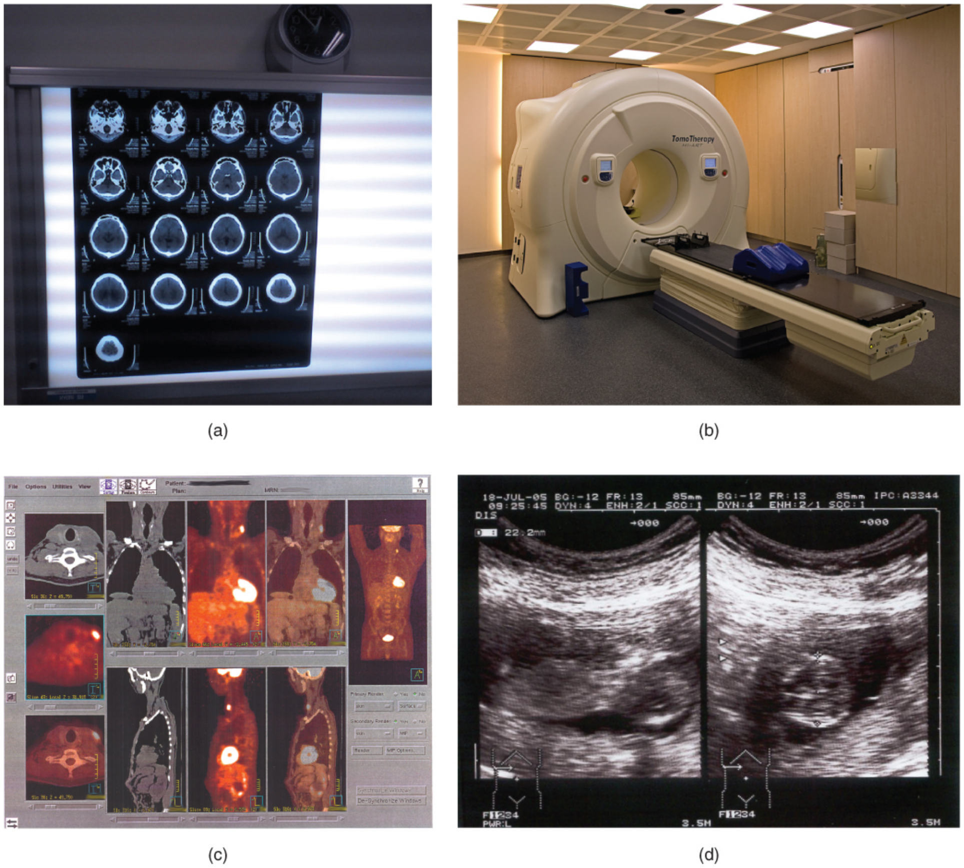
Improvements and enhancements of X-ray techniques have continued throughout the twentieth and twenty-first centuries. Although often replaced by more sophisticated imaging techniques, the X-ray remains a “workhorse” in medical imaging, especially for viewing fractures and for dentistry. The disadvantage of irradiation to the patient and the operator is now protected by proper shielding and by limiting exposure.

Modern Medical Imaging

X-rays can depict a two-dimensional image of a body region, and only from a single angle. In contrast, more recent medical imaging technologies produce data that is integrated and analyzed by computers to produce three-dimensional images or images that reveal aspects of body functioning.

Computed Tomography

Tomography refers to imaging by sections. **Computed tomography (CT)** is an imaging technique that uses computers to analyze several cross-sectional X-rays in order to reveal minute details about structures in the body ([link]**a**). The technique was invented in the 1970s and is based on the principle that, as X-rays pass through the body, they are absorbed or reflected at different levels. In the technique, a patient lies on a motorized platform while a computerized axial tomography (CAT) scanner rotates 360 degrees around the patient, taking X-ray images. A computer combines these images into a two-dimensional view of the scanned area, or “slice.”
Medical Imaging Techniques



(a) The results of a CT scan of the head are shown as successive transverse sections. (b) An MRI machine generates a magnetic field around a patient. (c) PET scans use radiopharmaceuticals to create images of active blood flow and physiologic activity of the organ or organs being targeted. (d) Ultrasound technology is used to monitor pregnancies because it is the least invasive of imaging techniques and uses no electromagnetic radiation. (credit a: Akira Ohgaki/flickr; credit b: “Digital Cate”/flickr; credit c: “Raziel”/Wikimedia Commons; credit d: “Isis”/Wikimedia Commons)

Since 1970, the development of more powerful computers and more sophisticated software has made CT scanning routine for many types of

diagnostic evaluations. It is especially useful for soft tissue scanning, such as of the brain and the thoracic and abdominal viscera. Its level of detail is so precise that it can allow physicians to measure the size of a mass down to a millimeter. The main disadvantage of CT scanning is that it exposes patients to a dose of radiation many times higher than that of X-rays. In fact, children who undergo CT scans are at increased risk of developing cancer, as are adults who have multiple CT scans.

Note:

A CT or CAT scan relies on a circling scanner that revolves around the patient's body. Watch this video to learn more about CT and CAT scans. What type of radiation does a CT scanner use?

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is a noninvasive medical imaging technique based on a phenomenon of nuclear physics discovered in the 1930s, in which matter exposed to magnetic fields and radio waves was found to emit radio signals. In 1970, a physician and researcher named Raymond Damadian noticed that malignant (cancerous) tissue gave off different signals than normal body tissue. He applied for a patent for the first MRI scanning device, which was in use clinically by the early 1980s. The early MRI scanners were crude, but advances in digital computing and electronics led to their advancement over any other technique for precise imaging, especially to discover tumors. MRI also has the major advantage of not exposing patients to radiation.

Drawbacks of MRI scans include their much higher cost, and patient discomfort with the procedure. The MRI scanner subjects the patient to such powerful electromagnets that the scan room must be shielded. The patient must be enclosed in a metal tube-like device for the duration of the scan (see [link]**b**), sometimes as long as thirty minutes, which can be uncomfortable and impractical for ill patients. The device is also so noisy that, even with earplugs, patients can become anxious or even fearful. These problems have been overcome somewhat with the development of "open" MRI scanning, which does not require the patient to be entirely enclosed in the metal tube. Patients with iron-containing metallic implants (internal sutures, some prosthetic devices, and so on) cannot undergo MRI scanning because it can dislodge these implants.

Functional MRIs (fMRIs), which detect the concentration of blood flow in certain parts of the body, are increasingly being used to study the activity in parts of the brain during various body activities. This has helped scientists learn more about the locations of different brain functions and more about brain abnormalities and diseases.

Note:

A patient undergoing an MRI is surrounded by a tube-shaped scanner. Watch this video to learn more about MRIs. What is the function of magnets in an MRI?

Positron Emission Tomography

Positron emission tomography (PET) is a medical imaging technique involving the use of so-called **radiopharmaceuticals**, substances that emit radiation that is short-lived and therefore relatively safe to administer to the body. Although the first PET scanner was introduced in 1961, it took 15 more years before **radio-pharmaceuticals**combined with the technique and revolutionized its potential. A radiopharmaceutical is a substance like a drink or dye that allow doctors a better idea of what is going on inside the body. The main advantage is that PET (see [link]**c**) can illustrate physiologic activity—including nutrient metabolism and blood flow—of the organ or organs being targeted, whereas CT and MRI scans can only show static images. PET is widely used to diagnose a multitude of conditions, such as heart disease, the spread of cancer, certain forms of infection, brain abnormalities, bone disease, and thyroid disease.

Note:

PET relies on radioactive substances administered several minutes before the scan. Watch this video to learn more about PET. How is PET used in chemotherapy?

Ultrasonography

Ultrasonography, sometimes called ultrasound or a sonogram, is an imaging technique that uses the transmission of **high-frequency sound waves** into the body to generate an echo signal that is converted by a computer into a real-time image of anatomy and physiology (see [link]**d**). Ultrasonography is the least invasive of all imaging techniques, and it is therefore used more freely in sensitive situations such as pregnancy. The

technology was first developed in the 1940s and 1950s. Ultrasonography is used to study heart function, blood flow in the neck or extremities, certain conditions such as gallbladder disease, and fetal growth and development. The main disadvantages of ultrasonography are that the image quality is heavily operator-dependent and that it is unable to penetrate bone and gas.

Chapter Review

Detailed anatomical drawings of the human body first became available in the fifteenth and sixteenth centuries; however, it was not until the end of the nineteenth century, and the discovery of X-rays, that anatomists and physicians discovered non-surgical methods to look inside a living body. Since then, many other techniques, including CT scans, MRI scans, PET scans, and ultrasonography, have been developed, providing more accurate and detailed views of the form and function of the human body.

Glossary

computed tomography (CT)
: medical imaging technique in which a computer-enhanced cross-sectional X-ray image is obtained

magnetic resonance imaging (MRI)
: medical imaging technique in which a device generates a magnetic field to obtain detailed sectional images of the internal structures of the body

positron emission tomography (PET)
: medical imaging technique in which radiopharmaceuticals are traced to reveal metabolic and physiological functions in tissues

ultrasonography
: application of ultrasonic waves to visualize subcutaneous body structures such as tendons and organs

X-ray

form of high energy electromagnetic radiation with a short wavelength capable of penetrating solids and ionizing gases; used in medicine as a diagnostic aid to visualize body structures such as bones